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ABSTRACT

Previous research has shown that the mean quantitative score on the Graduate Record Examinations (GRE) General Test or GRE quantitative score declines with the examinee's age, while the mean GRE verbal score remains relatively constant. It is assumed that the age-related decline in quantitative score is due, at least in part, to an increase in time away from formal academic work. One hypothesis is that taking formal quantitative coursework, such as that provided in graduate school, should cause nonrecent graduates' mean GRE quantitative scores to rebound to a level that is closer to that of recent college graduates. To test this hypothesis, 264 recent graduates and 66 nonrecent graduates whose preadmission GRE scores were available and who had some quantitative coursework were identified. All were administered an abbreviated General Test. The results failed to support the hypothesis. The difference between recent and nonrecent graduates' scores was just as pronounced, relative to scale, as was the difference on the first (preadmission) GRE test. Possible reasons for the results are discussed. One table and one figure present study findings. (Contains seven references.) (Author/SLD)

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Effects of Graduate Coursework on the GRE Quantitative Score for Recent and Nonrecent College Graduates

Gordon A. Hale
Donald A. Rock
and
Nicholas T. Longford

June 1991

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ETS Research Report 91-15

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Educational Testing Service, Princeton, New Jersey

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Educational Testing Service, Princeton, N.J. 08541

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Abstract

Previous research has shown that the mean quantitative score on the Graduate Record Examinations (GRE) General Test or GRE quantitative score, declines with age of the examinee, while the mean GRE verbal score remains relatively constant. It is assumed that the age-related decline in quantitative score is due, at least in part, to an increase in time away from formal academic work. A hypothesis that follows from this observation is that taking formal quantitative coursework, such as that provided in graduate school, should cause nonrecent graduates' mean GRE quantitative score to rebound to a level that is closer to that of recent graduates.

To test this hypothesis, recent and nonrecent college graduates who were currently enrolled in graduate programs in the social sciences, for whom preadmission GRE scores were available, and who had some quantitative coursework in those programs, were identified. Recent graduates were those who had graduated one year or less before taking the GRE, and nonrecent graduates were those who had graduated (or last received postgraduate schooling) seven years or more before taking the GRE. All students were administered an abbreviated General Test.

The results failed to support the hypothesis; the difference between 264 recent and 66 nonrecent graduates' quantitative performance on the second (abbreviated) GRE test was just as pronounced, relative to scale, as was the difference on the first (preadmission) GRE test. Possible reasons for these results are discussed.

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Robert McIntyre, Department of Psychology, Old Dominion University
Richard Mowsesian, Department of Educational Psychology, University of Texas
Douglas Nelson, Department of Psychology, University of South Florida
Judith Nipper, Department of Political Science and Public Administration, North Carolina State University
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Effects of Graduate Coursework on the GRE Quantitative Score for Recent and Nonrecent College Graduates

A subject of considerable interest to those involved in graduate admissions concerns the Graduate Record Examinations (GRE) General Test performance of graduate applicants who have been away from academic work for several years and tend to be older than the average applicant. The role of age in GRE test performance has been studied by Stricker and Rock (1985), who found that the same factors underlie test performance for younger and older examinees. However, age differences in mean performance have been observed. Clark (1984) and Hartle, Baratz, and Clark (1983) examined age differences in GRE test performance for students in different fields of study. They found that age was associated with a decline in quantitative scores but not verbal scores, and this was true for each of four major field groups: the arts and humanities, the social sciences, the biological sciences, and the physical sciences. (The analytic section did not exist when those studies were conducted.) Swinton (1987) also observed an age-related decline in quantitative but not verbal GRE scores.

An assumption underlying the present study is that an increase in amount of time away from academic work is associated with a decline in GRE quantitative scores. Students who have been away from formal schooling for several years presumably are out of practice in performing the kinds of quantitative reasoning activities that are required by the GRE General Test, because they have not had quantitative coursework for several years. (GRE verbal scores, on the other hand, probably remain high because of continued use of verbal skills outside of academic settings.) This assumption appears to be supported by comments on a questionnaire administered by Powers and Clark (1985) to a sample of test repeaters, many of whom believed that their quantitative skills had deteriorated because of the passage of time since taking any quantitative courses.

A hypothesis that follows is that, if nonrecent college graduates were to receive formal quantitative coursework, their potential to perform well on the quantitative portion of the GRE test should improve, due to resumption of activities that can facilitate thinking and reasoning in the quantitative domain. The degree of improvement, furthermore, should be greater than that observed for recent college graduates, who are presumably less out of practice in the quantitative area. In effect, then, GRE quantitative scores for nonrecent graduates should rebound to a level closer to that of the recent graduates, after resuming quantitative coursework. If this hypothesis were to be supported, it might be argued that the GRE test tends to underestimate the quantitative reasoning ability of nonrecent college graduates.

The hypothesis was tested in the present study using recent and nonrecent college graduates who were enrolled in graduate programs and for whom preadmission GRE scores were available. The students were administered an abbreviated GRE General Test after they had taken some quantitative coursework as part of their graduate studies. If the relative difference between groups in GRE quantitative performance were found to be less

pronounced for the second (abbreviated) GRE test than the first (preadmission) GRE test, the study's hypothesis would be supported.

Questionnaire data were also obtained about the extent of the students' quantitative experiences during graduate school and about other relevant background and experiential variables. These data were collected to provide statistical control for key factors in testing the hypothesis.

Analyses were also conducted on the GRE verbal scores. In light of evidence cited above, the relation between recent and nonrecent graduate groups in verbal scores was expected to be roughly the same for the second as for the first GRE test. Such a result would be consistent with the belief that verbal performance is not sensitive to the influence of recent formal schooling.

Method

Subjects

The subjects were students in graduate programs at 29 institutions. The programs chosen were all in disciplines in which (a) quantitative work, such as statistics, was required as part of the graduate curriculum (thus ruling out such areas as the arts and humanities) and (b) high GRE quantitative scores were not necessarily required for admission (thus ruling out such areas as mathematics and the physical sciences). Programs that met these criteria tended to be in the social sciences, broadly defined. Thus, the programs included 5 in educational psychology, 14 in other areas of psychology, 5 in political science, 3 in public administration, 1 in political science and public administration combined, and 1 in business. (As Hartle et al. [1983] found, 12.6% of graduate applicants age 22 or less, and 11.6% of applicants age 30 or more, planned to major in one of these five areas.)

In order to locate the participating programs, a search was first made of the GRE files to identify graduate departments to which large numbers of nonrecent college graduates had applied. A total of 66 programs that appeared to meet this condition as well as the above criteria were contacted. The 29 programs selected were ones that met those criteria, required the GRE General Test of all applicants, and agreed to participate.

The sample of students consisted of those who accepted the invitation to participate, with the knowledge that they would receive $30 for doing so. Among the criteria for inclusion of a student in the sample were the following:

1. The student must have been in his or her first through fourth year of enrollment in the participating graduate program.

2. The GRE General Test must have been taken between 0 and 3 years before enrollment in that program.

3. The student must have had some quantitative coursework in that program.

The predominant quantitative coursework taken was in statistics, which was a key area of the curriculum in every participating program. Additional areas of quantitative coursework included economics, accounting, and a few courses that stressed quantitative analysis in connection with management or research methods.

Given that participation was necessarily voluntary, the sample of students who actually took the test was smaller than the number who were eligible. In all, 330 (52%) of the 629 invited students participated. Three programs volunteered reasons for students' nonparticipation. Of the 105 eligible students in those three programs, 55% participated, 10% were out of town, 6% had a conflict, 2% were ill, 2% expressed an aversion to testing, 10% gave no reason, and 14% failed to respond to the invitation. Note, also, that because the sample included only students who were enrolled in the participating programs, the range of GRE scores represented in the sample did not extend below the level required for admission to those programs.

Comparison groups. Two groups of students were included in the study: (a) "recent graduates" (N = 264) and (b) "nonrecent graduates" (N = 66), defined primarily by the time elapsed between completion of the bachelor's degree and administration of the first, or preadmission, GRE General Test (defined below). For the recent graduates, the time elapsed was one year or less, and for the nonrecent graduates, seven years or more.

Included in the group of recent graduates were students who had graduate coursework after the bachelor's degree before enrolling in their current graduate programs, as long as the other graduate coursework occurred after taking the first GRE test, and the criteria listed above were met. The group of nonrecent graduates included students who had other graduate coursework before enrolling in their current programs, as long as the above criteria were met and either (a) the other graduate coursework occurred after the first GRE test was taken, or (b) at least seven years had elapsed between completion of the other graduate coursework and the date of the first GRE test.

Seventy-two percent of the recent graduates were enrolled in one of the 19 participating programs in psychology or educational psychology versus 28% in one of the 10 programs in political science, public administration, or business. For nonrecent graduates the analogous percentages were 68 and 32, respectively.

Materials

First GRE test. The GRE General Test taken prior to admission to the current graduate program is here termed the "first GRE test." It was an operational test and was taken at one of the regular test administrations between April 1981 and June 1986. The scores used in the present data

analyses were the GRE quantitative score (which was based on two 30-minute quantitative sections) and the GRE verbal score (which was based on two 30-minute verbal sections); the analytical score was not used. Scores on the 200-800 GRE scale were employed in data analyses.

Second GRE test. The abbreviated GRE General Test, administered in the spring of 1987 to the study sample, is here termed the "second GRE test." It consisted of a 38-item verbal section (30 minutes) and a 30-item quantitative section (30 minutes), presented in that order for all students. Raw scores on each section of this test were used in the data analyses.

The two sections were taken from a previously disclosed GRE General Test. The test form selected was one that the students were extremely unlikely to have encountered when they previously took the test. This test was administered in a special session, which was conducted at a time that was convenient for the largest number of eligible students. In a few institutions, two separate testing sessions were conducted in order to maximize the opportunity for eligible students to participate. The test was administered by the on-site project coordinator or an associate, with an additional proctor present wherever the test session involved more than 35 students. Testing instructions were taken from the GRE Supervisor's Manual to ensure that the test procedures would be similar to those used in an operational GRE General Test. Students responded by gridding their choices on a separate answer sheet.

For both the first and second GRE tests, the quantitative section, as described in the GRE Information Bulletin, was "designed to measure basic mathematical skills, understanding of elementary mathematical concepts, and ability to reason quantitatively and to solve problems in a quantitative setting. The mathematics required does not extend beyond that assumed to be common to the mathematics background of almost all examinees. The questions include three broad content areas: arithmetic, algebra, and geometry" (Educational Testing Service, 1990/1991, p. 36). In short, the knowledge required by the quantitative section relates to the kind of material covered in the typical mathematics curriculum in high school and earlier.

The verbal section was "designed to test one's ability to reason with words in solving problems.... Such factors as knowledge of words and practice in reading ...define the limits within which one can reason..." (Educational Testing Service, 1990/1991, p. 31).

Questionnaires. Prior to taking the second GRE test the students answered a short set of personal background questions. Then, immediately after taking the test, the students answered several questions dealing with current and previous quantitative experiences. In addition, for most students, data were available from the set of background questions they answered when they registered to take the first GRE test. These questionnaires contributed the following variables, which were used as covariates in the analyses to be described in the Results section.

(1) sex

(2) degree objective (doctorate vs. other)

(3) graduate major (psychology vs. combination of political science, public administration, and business)

(4) ethnic group (White and Asian American combined vs. other subgroups combined; grouping based on previously observed quantitative performance of various subgroups)

(5) English as best language (student's reported best language was English vs. any other language)

(6) parent education, defined as the higher of the levels attained by father and mother (1: did not graduate from high school; 2: high school graduate; 3: beyond high school but did not graduate from a four-year college; 4: graduate of a four-year college; 5: beyond college but did not receive a graduate or professional degree; 6: graduate or professional degree)

(7) amount of quantitative coursework in the current graduate program (expressed in course years, where one semester = 1/2 year, one quarter = 1/3 year)

(8) amount of quantitative coursework in another graduate program (if taken after the first GRE test; defined in same way as in Item 7)

(9) months since completing last quantitative course

Results

Table 1 presents the mean scores on the first and second GRE tests separately for recent and nonrecent graduates.

Group difference in first GRE quantitative score. The results of initial interest were those bearing on the assumption underlying the study--that nonrecent graduates should have a lower mean quantitative score on the first (preadmission) GRE test than recent graduates. The data taken from the first GRE test conform to that assumption, as can be seen by inspection of Table 1.

An analysis of covariance was conducted to test this assumption. The dependent variable was the first GRE quantitative score, and the independent factor was the Recency Group (i.e., recent vs. nonrecent graduates). Several covariates were used to control for the influence of other student characteristics. These variables, defined in the Method section, included (a) biographical variables: sex, ethnic group, English as best language, and parent education and (b) educational status variables: degree objective and graduate major field. The verbal score on the first GRE test was also

used as a covariate, to verify (if true) that the recent graduates' superior quantitative scores were not just attributable to higher proficiency in general. The analysis used a regression procedure; input to the regression program was a missing data variance-covariance matrix.

Results of this analysis showed that nonrecent graduates' scores were significantly lower than those of the recent graduates, $F(1,308) = 9.31$, $p<.01$. (The difference between adjusted means was .38 standard deviations--i.e., 38% of the pooled standard deviation of first GRE quantitative score.) Thus, the data supported the study's underlying assumption that GRE quantitative scores of nonrecent graduates would be lower than those of recent graduates, controlling for verbal proficiency as well as key student characteristics.

An analysis of variance was also conducted with first GRE quantitative score as the dependent variable, Recency Group as an independent factor, and no covariates. The superiority in performance of recent graduates was found to be significant in this analysis as well, $F(1,315) = 4.45$, $p<.05$, with a difference between means of .30 standard deviations. Thus, the difference between groups in first GRE quantitative score was significant even without controlling for verbal score and the other student characteristics.

Group difference in second relative to first GRE quantitative score. The study's principal hypothesis was that the difference between recent and nonrecent graduates would be less pronounced for the second GRE quantitative score than the first, due to a rebound in quantitative performance for the nonrecent graduates. In selecting an appropriate significance test, the difference in scales for the two tests made it impossible to examine the amount of change from the first to the second test and to compare groups with respect to the amount of change. Therefore, the hypothesis was tested via analysis of covariance, using the second GRE quantitative score as a dependent variable, Recency Group as an independent factor, and first GRE quantitative score as a covariate. In such an analysis, the study's hypothesis would be supported if a group difference in favor of nonrecent graduates were observed in the second GRE quantitative score, with the group difference in the first GRE quantitative score eliminated by the covariance adjustment. However, the analysis showed no significant difference between recency groups in second GRE quantitative score, controlling for first GRE score, $F(1,315) < 1$, thus failing to support the hypothesis. (The difference between adjusted means equaled .00 standard deviations.)

An additional analysis of covariance was also conducted to control for possible group differences in the nature of the students or in other factors that might influence quantitative performance. Again, the second GRE quantitative score was the dependent variable, Recency Group was an independent factor, and first GRE quantitative score was the principal covariate. Other covariates included (a) biographical variables: sex, ethnic group, English as better language, and parent education; (b) educational status variables: degree objective, and graduate major field; (c) variables associated with amount of quantitative coursework between the first and second GRE tests: amount of quantitative coursework in the current graduate program, and amount of quantitative coursework in any other

graduate program; and (d) a variable reflecting time elapsed since taking quantitative coursework in the current program: months since last quantitative course. The results showed that recent and nonrecent graduates did not differ in second GRE quantitative score, adjusting for first GRE quantitative score and the other covariates, $F(1,315) < 1$. (The difference between adjusted means equaled only .03 standard deviation in favor of nonrecent graduates.) Thus, this analysis of covariance was consistent with the first in failing to support the study's hypothesis.

The lack of support for the hypothesis is also evident in Figure 1, which shows the regression of second GRE quantitative score on first GRE quantitative score. The fact that the regressions for recent and nonrecent graduates practically lay along the same line shows that the difference between groups, relative to scale, was approximately the same for both tests.

Analyses of verbal scores. It was also useful to conduct analyses of variance on the verbal scores, as these scores help provide a frame of reference for understanding the effects involving the quantitative scores. In the first analysis, the dependent variable was the first GRE verbal score, the independent factor was Recency Group, and the covariates were (a) biographical variables: sex, ethnic group, English as better language, and parent education and (b) educational status variables: degree objective and graduate major field. The results showed that nonrecent graduates' verbal scores on the first GRE test were significantly higher than those of the recent graduates, controlling for the covariates, $F(1,309) = 15.92$, $p<.001$, with the difference between adjusted means equal to .54 standard deviations.

In the second analysis, the dependent variable was the second GRE verbal score, the independent factor was Recency Group, and the covariates were: (a) first GRE verbal score, (b) the biographical variables listed above, and (c) the educational status variables listed above. In this case, the group difference was nonsignificant, $F(1,308) < 1$, and was only .06 standard deviation in favor of nonrecent graduates. Apparently, the superiority of nonrecent graduates on the first GRE verbal score could almost entirely account for their superiority on the second GRE verbal score. Thus, as expected, the verbal scores of recent and nonrecent graduates were not differentially affected by the resumption of formal study.

Comparison of participants and nonparticipants. To address the issue of sample representativeness, comparisons were made between (a) the final sample who participated, and (b) students who were tentatively identified as meeting the study's criteria but did not participate. Note that the initial decision to invite a student was based only on preliminary information (which was occasionally inaccurate) about the time elapsed between the bachelor's degree and the first GRE test. The final selection was based on the students' responses to certain background questions, and because this information was available for participants only, a comparison of recent and nonrecent graduates could not be made for the nonparticipants.

Mean GRE scores for the 330 participants and 299 nonparticipants were GRE verbal: 583 vs. 566 (*SD*s = 97 and 106), and GRE quantitative: 596 vs. 568 (*SD*s = 93 and 94). The difference between groups was significant beyond the .05 level for both scores; GRE verbal: $t(627) = 2.07$, GRE quantitative: $t(627) = 3.72$. Apparently, those who participated tended to score higher on the preadmission GRE test by about .17 standard deviation for the verbal score and .30 standard deviation for the quantitative score. Thus the group of students that participated in the study was not a random sample of all eligible students in the cooperating departments. Neither, however, was it greatly different from the group of nonparticipants. Therefore, it seems reasonable to assume that the participants here comprised an appropriate sample with which to test the study's hypothesis.

Discussion

An assumption underlying the study was that nonrecent college graduates would have lower quantitative scores on the first GRE test than recent college graduates, due to their lack of recent formal experiences in the quantitative domain. Following this assumption, it was hypothesized that resuming formal quantitative coursework would, in effect, cause a rebound in quantitative performance of nonrecent graduates, reducing the gap between recent and nonrecent graduates in GRE quantitative scores.

The results did support the underlying assumption, in showing that quantitative scores on the first GRE test were significantly lower for nonrecent than recent graduates. However, the results failed to support the study's hypothesis regarding a rebound effect for nonrecent graduates. The group difference in quantitative scores on the second GRE test was roughly the same, relative to scale, as the difference on the first GRE test. Indeed, there was not even a trend in the direction of support for the hypothesis, as the *F* statistic in the analysis of covariance was less than 1.

Interpretation of these results must take into account the power of the analyses. In deciding on the size of effect one wishes to detect, perhaps the smallest effect that could be considered practically meaningful would be one-fourth of a standard deviation (i.e., difference between adjusted means in the analysis of covariance of .25 standard deviation units) . Following Cohen (1977), the present sample size yielded a power of only .44 for detecting such an effect at the .05 level. In order to achieve a power of .80 for detecting such an effect--a power level suggested by Cohen as desirable--the sample size would need to be more than twice as large as that of the present study, assuming the same ratio of recent to nonrecent graduates as was used here. On the other hand, the power for detecting an effect of medium size by Cohen's definition, or one-half of a standard deviation, was .95 with the present sample.

Thus, it appears reasonable to reject, with some confidence, the possibility that quantitative coursework causes a medium-sized or larger

rebound effect in nonrecent graduates' GRE quantitative scores. It is still possible, however, that the hypothesized rebound effect exists, but that the effect is relatively small, and the present sample size was insufficient to detect it. Whether the study could be readily expanded to include a much larger sample is open to question, as a great deal of time and resources were required even to locate the present sample. Nevertheless, given that the expected rebound effect for nonrecent graduates may be a real phenomenon but is of limited size, the study's hypothesis cannot be dismissed without further investigation.

Although the conclusions drawn here must therefore be regarded as tentative, it is still useful to entertain possible reasons for the study's negative results. In this regard, it is important to draw a distinction between two types of hypotheses regarding facilitation of GRE scores for nonrecent graduates. One involves presentation of refresher work directed specifically toward improvement of performance on the GRE. The other, which was the focus of the present study, involves a more general quantitative facilitation effect. The present hypothesis, in effect, was that graduate quantitative coursework would provide a milieu that could induce nonrecent graduates to recover a general facility in the quantitative domain. That is, the kinds of experiences encountered in quantitative coursework would help these students to regain a familiarity with performing quantitative activities and to redevelop their facility to think and reason in the quantitative area. This hypothesis failed to receive support in the present study.

It is another issue, however, whether nonrecent graduates' GRE quantitative scores would rebound upon the students taking courses that cover specific facts and formulas from the content areas of the GRE General Test. Information bearing on this issue was not available from the present study. The background knowledge required by the GRE quantitative section involves material covered during and prior to high school in arithmetic, algebra, and geometry. By contrast, graduate courses in statistics, the predominant quantitative courses taken by students in the present sample, cover concepts and equations associated with such things as measures of central tendency and variability, measures of relationship, and inferential statistics. Thus, the content of graduate statistics courses overlaps very little with the content covered by the GRE test, as is also true of other graduate courses. It remains a plausible hypothesis for further research that nonrecent graduates' GRE quantitative performance would rebound upon taking refresher coursework in the specific content areas covered by the GRE test.

Another possible reason for the present study's negative results has to do with the nature of the students in the two groups being compared here. The initial difference in GRE quantitative scores between the recent and nonrecent graduates may have been due, not to the latter group's being out of practice, but to basic differences in unmeasured characteristics of these two groups. Those who delay their graduate work may be quite different in nature from those who begin graduate work immediately after college. The present analyses were designed to control for key variables on which these groups may have differed, by using these variables as covariates.

Nevertheless, there may be differences in the nature of recent and nonrecent graduates that were not, or could not, be properly controlled in assessing differences between these groups.[1]

It is useful also to consider the verbal scores when comparing the recent and nonrecent graduate groups, partly to understand the observed group differences in quantitative scores. In contrast with the quantitative scores, the verbal scores of nonrecent graduates were higher than those of recent graduates, an effect that was apparent for both the first and second GRE tests. This result shows that, as expected, the nonrecent graduates were not less proficient in general than the recent graduates, but were less proficient only in the quantitative domain. At the same time, the result provides support for the view that continuation of formal coursework is not essential for maintenance of verbal skills.

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[1]Age could not be included as a covariate in the analyses because, as expected, it was strongly confounded with graduation recency. An analysis might have been done comparing the nonrecent graduates with the recent graduates of comparable ages (28 years and older), but the latter group contained only 35 of the 264 recent graduates, which was too few to permit a meaningful analysis, and these 35 students undoubtedly would be quite unrepresentative of the population of recent college graduates. Regardless, the objectives of the present study were believed to be best served by comparing a representative sample of recent graduates with a representative sample of nonrecent graduates, with age allowed to covary naturally with graduation recency, as was done here.

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Table 1

Scores on the First and Second GRE Tests for Each Subgroup

	Recent Graduates (N = 264)	Nonrecent Graduates (N = 66)
First GRE Quantitative Score		
Mean	601.02	573.48
SD	91.74	97.78
Second GRE Quantitative Score		
Mean	20.71	19.94
SD	3.66	4.18
First GRE Verbal Score		
Mean	573.98	617.88
SD	92.67	105.44
Second GRE Verbal Score		
Mean	26.79	28.53
SD	5.02	5.06

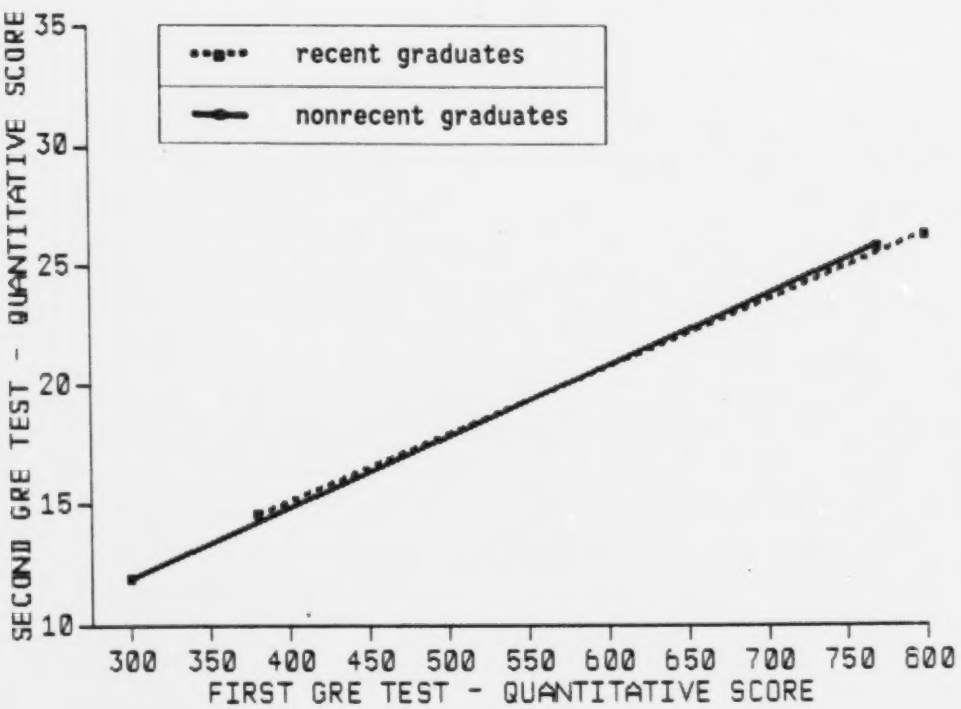

Figure 1. Regression of second GRE quantitative score on first GRE quantitative score for recent and nonrecent graduates.

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